AMENDMENTS TO THE DRAWINGS

Appended hereto as attachments are replacement formal drawing sheets to replace the drawings that were included in the PCT application. The PCT drawings have only been amended to replace the handwritten figure designations and reference numerals with typographical characters.

REMARKS

The substitute specification together with the amended claims and amended drawings place the present U.S. national phase application in better form for examination on the merits.

Based upon the specification, drawing, and claim amendments to this national phase application, it is believed that the amended specification, the amended drawings, and the amended claims conform with U.S. formal requirements. Early and favorable action on this application is respectfully requested.

Should the examiner have any question after considering this Preliminary Amendment, he is cordially invited to telephone the undersigned attorney so that any such question can be quickly resolved in order that the present application can proceed toward allowance.

Respectfully submitted,

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Attachments: Attachment A
Attachment B
Replacement drawing sheets including changes

ATTACHMENT B

SUBSTITUTE SPECIFICATION
(Showing All Changes Made to the Specification and Abstract in International Application No. PCT/SE2005/001194)

A METHOD PERTAINING TO COMBUSTION, AND A BURNER

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The present invention relates to a method pertaining to combustion, and to a burner. More specifically, the invention relates to a method and to a burner for the combustion of oxygen gas in respect of heating furnaces.

DESCRIPTION OF THE RELATED ART

When combusting hydrocarbons in combination with high oxygen ~~concentration~~ concentrations, flame temperatures in excess of 2000 degrees C are normally reached, together with furnace atmospheres of very high partial pressures of carbon dioxide and steam. This results in drawbacks, such as high ~~NOx~~ NO_x -contents and local overheating problems.

It is highly desirous to design burners that have emission-diminishing properties. The present invention satisfies ~~this desideratum~~ that desire.

SUMMARY OF THE INVENTION

Accordingly, the present invention relates to a method pertaining to the combustion of a fuel with an oxidant in a heating furnace, ~~where~~ wherein the fuel and the oxidant are delivered to a burner head ~~, and is characterized in that in~~ . In a first method step fuel and ~~oxydant~~ oxidant are ~~caused to be~~ emitted from the burner head

in the close proximity of one another, so that the ~~process of~~ combustion ~~will take~~ process takes place essentially close to and at a small distance ~~out~~ away from the burner head until ~~there~~ a temperature is reached in the furnace space ~~a temperature~~ that exceeds the spontaneous combustion temperature of the fuel ~~and in that in~~ . In a second method step the fuel and the oxidant are ~~then caused~~ instead ~~to be~~ emitted from the burner head in mutually spaced relationship, so that the ~~process of~~ combustion ~~will take~~ process takes place essentially at a distance from the burner head corresponding to at least the diameter of the burner head and ~~out~~ away from the burner head.

The invention also relates to a burner ~~of the kind and with the general features set forth in claim 9~~ head that includes a fuel supply nozzle and a first oxidant outlet opening in close proximity to the fuel nozzle, so that combustion takes place close to and at a small distance away from the burner head. The burner head also includes further oxidant outlet openings that are located at a distance from the fuel nozzle, so that combustion takes place at a distance from the burner head corresponding to at least the diameter of the burner head and outward of the burner. The burner is adapted to deliver the oxidant at an overpressure of at least 2 bar.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail, partly with reference to exemplifying embodiments of the invention illustrated in the accompanying drawings, in which:

- Fig. 1 is a straight-on, front view of a burner head according to a first embodiment;

- Fig. 2 is a straight-on , front view of a burner head according to a second embodiment;

- Fig. 3 is a diagrammatic illustration of a burner head and a flame as seen from one side when the burner is operated in a first manner; and

- Fig. 4 is a diagrammatic illustration of a burner head and a flame as seen from one side when the burner is operated in a second manner.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The inventive method thus ~~pertains~~ relates to the combustion of a fuel with an oxidant in a heating furnace, in which the fuel and the oxidant are delivered to a burner head. The burner head is mounted in a known ~~matter~~ manner in a furnace wall, so that the flame produced in the combustion process will extend into the furnace chamber.

The invention is characterized in that the combustion process takes place in two steps, where the second step affords advantages over the known technology.

In a first method step, fuel and oxidant are emitted from the burner head in close relationship with one another, so that the process of combustion ~~will~~ essentially ~~take~~ takes place close to and slightly spaced from the burner head. This method is known per se, in which the burner is designated as an "Oxy-fuel" -burner.

In this first step of the method, the burner is operated until a temperature exceeding the spontaneous combustion temperature of the fuel is reached in the furnace chamber.

The second step of the combustion process ~~may~~ can conveniently be initiated when the furnace temperature is above roughly 750 degrees C.

According to the invention, this second method step is carried out when ~~this~~ that temperature or a still higher temperature has been reached. In this second method step, the fuel and the oxidant are ~~caused~~ instead ~~to be~~ emitted from the burner head at a distance from each other, so that combustion ~~will take~~ takes place generally at a distance from the burner head that corresponds at least to the diameter of the burner head and ~~out~~ away from the burner head.

It is preferred that in the first method step the fuel is ~~caused to be~~ emitted from a fuel nozzle 2 in the burner head 1, and the oxidant is ~~caused to be~~ emitted from oxidant outlet openings 3 placed concentrically around the fuel nozzle 2 ~~; see figure~~ , as shown in Figure 1.

It is also preferred that in the second method step, the fuel is ~~caused to be~~ emitted from a fuel nozzle 2 in ~~a~~ the burner head 1, and ~~that~~ the oxidant is emitted from oxidant outlet openings 4, 5 located on one side of and at a distance from ~~said~~ fuel nozzle 2 ~~; see figure~~ , as shown in Figure 1.

According to one preferred embodiment of the invention, the oxidant outlet openings 4, 5 are ~~comprised of~~ Laval nozzles or venturi-nozzles.

The opening 6 functions to monitor the flame.

According to one preferred embodiment of the invention, the oxidant outlet openings 4, 5 are spaced from the fuel nozzle 2 ~~by~~ at a distance that exceeds half the diameter of the burner head.

It has been found that a distance of about 40 mm suffices to ~~afford~~ provide the desired effect.

The burner thus permits two different *modus operandi,* partly as a typical oxy-fuel burner and partly as a burner which functions to produce a flame of essentially lower maximum temperature. ~~This~~ That lower flame temperature is adapted to ~~lie beneath~~ be less than the temperature at which the formation of ~~NOx~~ NO_x is limited by the reaction kinetics, ~~this~~ that temperature being about 1550 degrees C.

~~This~~ That result is achieved by the ~~aforesaid~~ above-mentioned placement of the ~~oxygen~~ oxidant outlet openings 4, 5 and the fuel nozzle 2, whereby fuel and oxygen are combusted further away from the burner head in comparison with a conventional oxy-fuel-combustion process. ~~This~~ That result is illustrated in ~~figures~~ Figures 3 and 4, ~~where figure~~ wherein Figure 3 illustrates the mutual relationship between the length and the propagation of the ~~flames~~ flame 7 ~~, 8~~ in ~~the~~ respect of oxy-fuel-combustion, and ~~figure~~ Figure 4 illustrates the mutual relationship between the length and the propagation of ~~said flames~~ flame 8 in the case of combustion according to the second step of the inventive method.

The concept of the invention resides in lowering the oxygen content in the combustion zone, despite the oxidant having an oxygen content of more than 80%, by virtue of separation, high pressure, and an optimized nozzle placement. ~~This~~ That is achieved with a ~~nozzle~~ burner head configuration that ~~affords~~ results in a high subpressure on those surfaces of the ~~nozzle~~ burner head 1 that lack medium-emitting nozzles. As a result of ~~the~~ that subpressure, flue gases are sucked in from the furnace atmosphere and quickly mix with the ~~out flowing~~ outflowing media and therewith create

turbulence. The mixing medium, i.e., the furnace atmosphere, typically has an oxygen content of 0.5 - 10%. The remainder of the gas is ~~comprised of~~ CO_2 and H_2O and N_2 in varying ~~mixtures~~ proportions.

Because CO_2, H_2O, and N_2 do not actively take part in the combustion process, ~~these~~ those constituents act as "combustion retardants." [[.]] The dilution of the oxygen and the fuel is very high. Typically, oxygen concentrations of 7 - 15 % are reached in the combustion process, despite the use of pure oxygen. When applying the present invention there is obtained at process temperatures above ~~said~~ the spontaneous combustion temperature a diffused but controlled combustion that significantly lowers the formation ~~NOx~~ of NO_x gases, primarily NO and NO_2.

As a result, fuel and oxidant ~~will be~~ are mixed with the furnace flue gases before the fuel and oxidant gases meet one another. ~~This gives~~ That provides a larger and colder flame 8 in spite of the efficacy corresponding to that achieved when combustion is effected according to known technology. The ~~nozzles~~ fuel nozzle 2 and oxidant openings 3, 4, and 5 can be ~~directed~~ conveniently directed straight forward, i.e., they need not be directed away from or towards each other, although they ~~may~~ can be angled towards or away from the longitudinal axis of the burner head.

According to one preferred embodiment of the inventive method, the ~~oxydant~~ oxidant is gaseous and is ~~given~~ at an oxygen concentration of 85% or higher.

According to one significant feature of the inventive method, the oxidant is delivered to the burner at a pressure of at least 2 bar overpressure. Because the flame temperature is lower and the mixture of gas in the furnace volume is greater than in the case of oxy-fuel-combustion, the formation of ~~NOx~~ NO_x is minimized while

the temperature differences in the furnace space are dramatically lowered at the same time.

In comparison with conventional combustion devices used in industrial processes, application of the inventive method results in a lowering of ~~NOx~~ NO_x formations by more than 90 %, without impairing the efficiency of the process and without the supply of substances other than those required for the combustion.

A burner ~~nozzle~~ head according to the present invention is no ~~larges~~ larger than a known burner head for oxy-fuel-combustion. In a preferred embodiment of the invention, the burner ~~nozzle~~ head has a diameter of about 70 mm.

The compact ~~method~~ structure enables the invention to be applied in equipment already possessed by the user. Moreover, the equipment can be placed in a small, water-cooled protective casing for application at very high process temperatures.

The ~~aforesaid~~ above-mentioned advantages are achieved in accordance with the invention with a selected fuel, which can be solid fuel, gaseous fuel, or liquid fuel. The inventive arrangement can replace existing combustion systems in ~~principal~~ principle without re-constructing the furnace equipment used for the process.

It is beneficial when the fuel used is oil, propane, or natural gas.

The burner head shown in ~~figure~~ Figure 1 is intended for oil as the fuel.

Figure 2 shows a burner head 10 for natural gas as fuel. The fuel nozzle 11 is intended for natural gas. The outlet openings 12, 13, 14 are intended for the oxidant. The opening 15 is intended for monitoring the flame and the opening 16 is intended for a pilot flame.

Because the oxidant openings and the fuel nozzles can be directed straight forwards, ~~there is obtained~~ a ~~construction~~ burner head is achieved that is inexpensive, that is easy to maintain, and that can be applied in existing processes without requiring measures other than the exchange of the ~~nozzle construction~~ burner head.

The oxidant is injected into the combustion space via one or more ~~nozzles~~ oxidant openings in the form of Laval nozzles or venturi nozzles. The oxidant will preferably be ~~under~~ at an overpressure of at least 2 bar. The higher the pressure, the better the efficacy of the invention. A preferred pressure for normal applications is 4 - 5 bar. The fuel is injected via conventional fuel nozzles at the pressure available.

Although the invention has been described above with reference to a number of exemplifying embodiments it will be understood that the design of the burner head can be varied. For instance, the burner head ~~may~~ can include more oxidant outlet openings than those shown. Moreover, the placement of the fuel nozzle ~~may~~ can be different ~~to~~ from that shown in the drawings.

It will therefore be understood that the present invention is not restricted to the embodiments described above, but can be varied within the scope of the accompanying claims.

~~CLAIMS~~

What is claimed is:

ABSTRACT OF THE DISCLOSURE

~~The present invention relates to a~~ A method ~~pertaining~~ and apparatus relating to the combustion of a fuel with an oxidant in a heating furnace, wherein the fuel and the oxidant are delivered to a burner head.

~~The invention is characterized in that in~~ In a first method step fuel and oxidant are ~~caused to be~~ emitted from the burner head ~~(1; 10)~~ in ~~the~~ close proximity ~~of~~ to each other, so that combustion ~~will~~ essentially ~~take~~ takes place close to and at a small distance outward of the burner head, and until ~~there~~ a temperature is reached in the furnace space ~~a temperature~~ that exceeds the spontaneous combustion temperature of the fuel ~~; and in that in~~ . In a second method step the fuel and the oxidant are ~~caused to be~~ instead emitted ~~instead~~ from the burner head ~~(1; 10)~~ at a mutual distance apart, so that combustion ~~will essentially take~~ takes place at a distance from the burner head corresponding to at least the diameter of the burner head and ~~outwards~~ outward of the burner head.

~~(Fig. 1 for publication)~~